An Engineering Approach to Abatement of Estrogenic EDCs in Wastewater

Paul McCauley

Who is involved?

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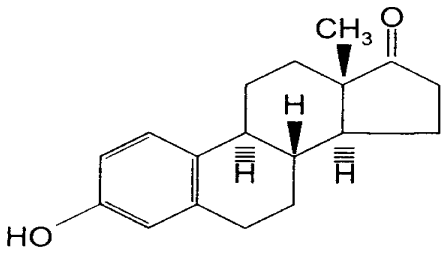
Cindy Boardman	Biologist	Univ. Cinti.
Makram Suidan	Environmental Engineer	Univ. Cinti.

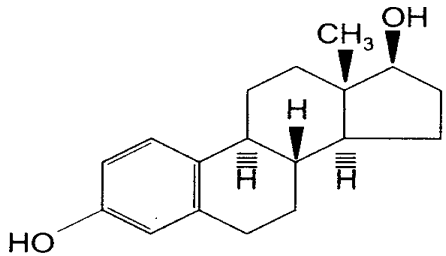
The Problem

- Publicly Owned Treatment Works (POTW) Discharges appear to have Estrogenic Effects on Several Species of Fish
- This effect appears to be mediated through the estrogen receptor
- Compounds Suspected of these Estrogenic effects include Estrogens and there metabolites and Alkylphenols, there ethoxylates and metabolites

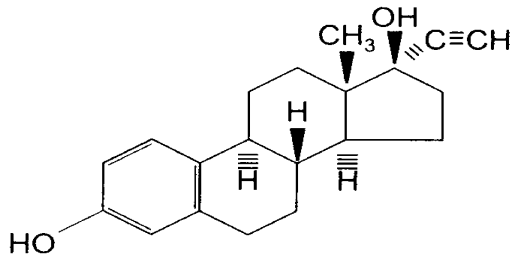
Estrogens and Androgens



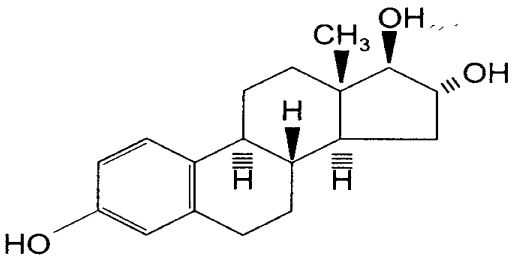
Estrone



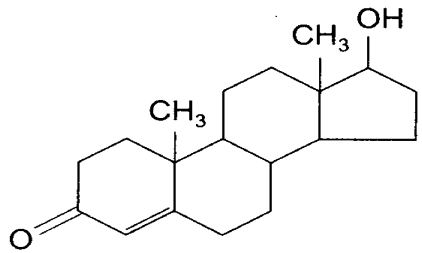
17-β-Estradiol



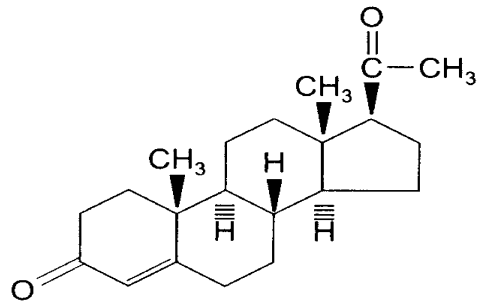
17-α-Ethynylestradiol



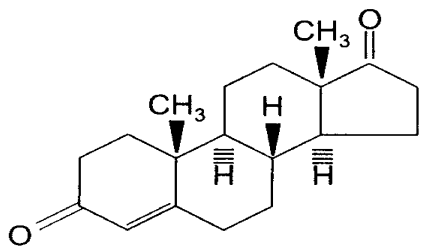
Estriol



Testosterone

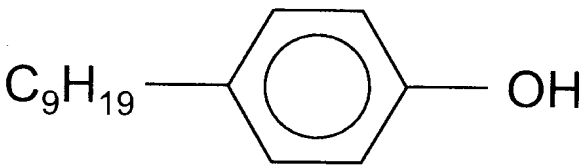


Progesterone

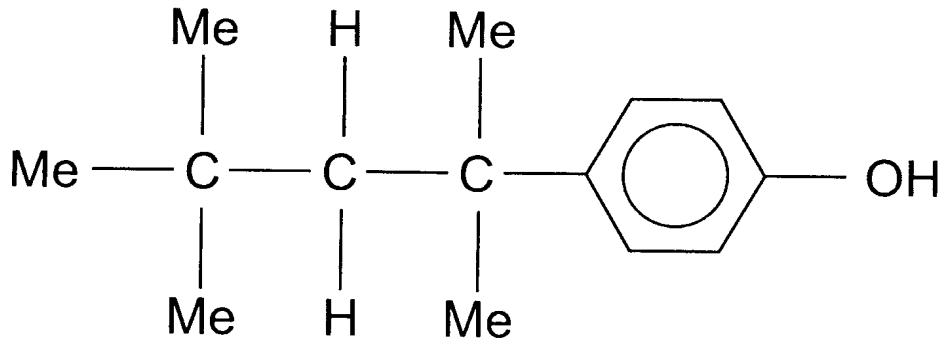


Androstenedione

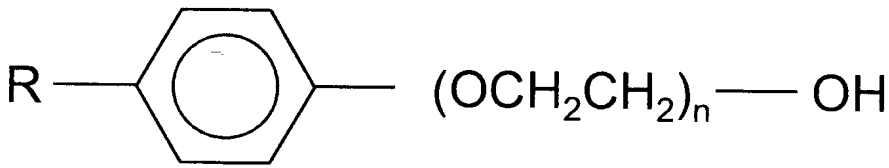
Alkylphenols



4-nonylphenol (NP)



4-*tertiary*-octylphenol (OP)



R=C_9H_{19}, nonylphenol ethoxylates (NPEO)
R=C_8H_{17}, octylphenol ethoxylates (OPEO)

Long Term Objectives

- 1 To determine the fate of Estrogenic EDCs (including Estrogens, there metabolites; Alkylphenols, there ethoxylate esters and metabolites) during wastewater treatment
- 2 To fashion an engineering solution to Estrogenic EDC discharge in wastewater and sludge.

Basic Approach

- Develop assays for the suspect agents
- Construct pilot scale wastewater treatment systems to model metabolic pathways.
- Assay samples from selected and representative POTWs to determine if the pilot scale system is modeling POTWs
- Optimize pilot scale wastewater treatment systems for treating estrogenic EDCs
- Make recommendations for improving EDC treatment in POTWs

The Proposed Assays

- Steroid analysis using solid phase extraction and GC/mass spectrometry
- Nonylphenol ethoxylate analysis using solid phase extraction and normal phase HPLC.
- Fathead minnow using estrogen receptor mediated induction of vitellogenin by measuring messenger RNA assay (NRML)
- Recombinant Yeast assay

Steroid Analysis

- Liquid and Solid fractions shall be separated and analyzed separately.
- Solids shall be extracted
- All fractions will then be concentrated using solid phase extraction (SPE) Extracts from the SPE will be derivatized and analyzed by GC Mass Spectrometry
- Goals for detection thresholds is 1 ng/L for each steroid.

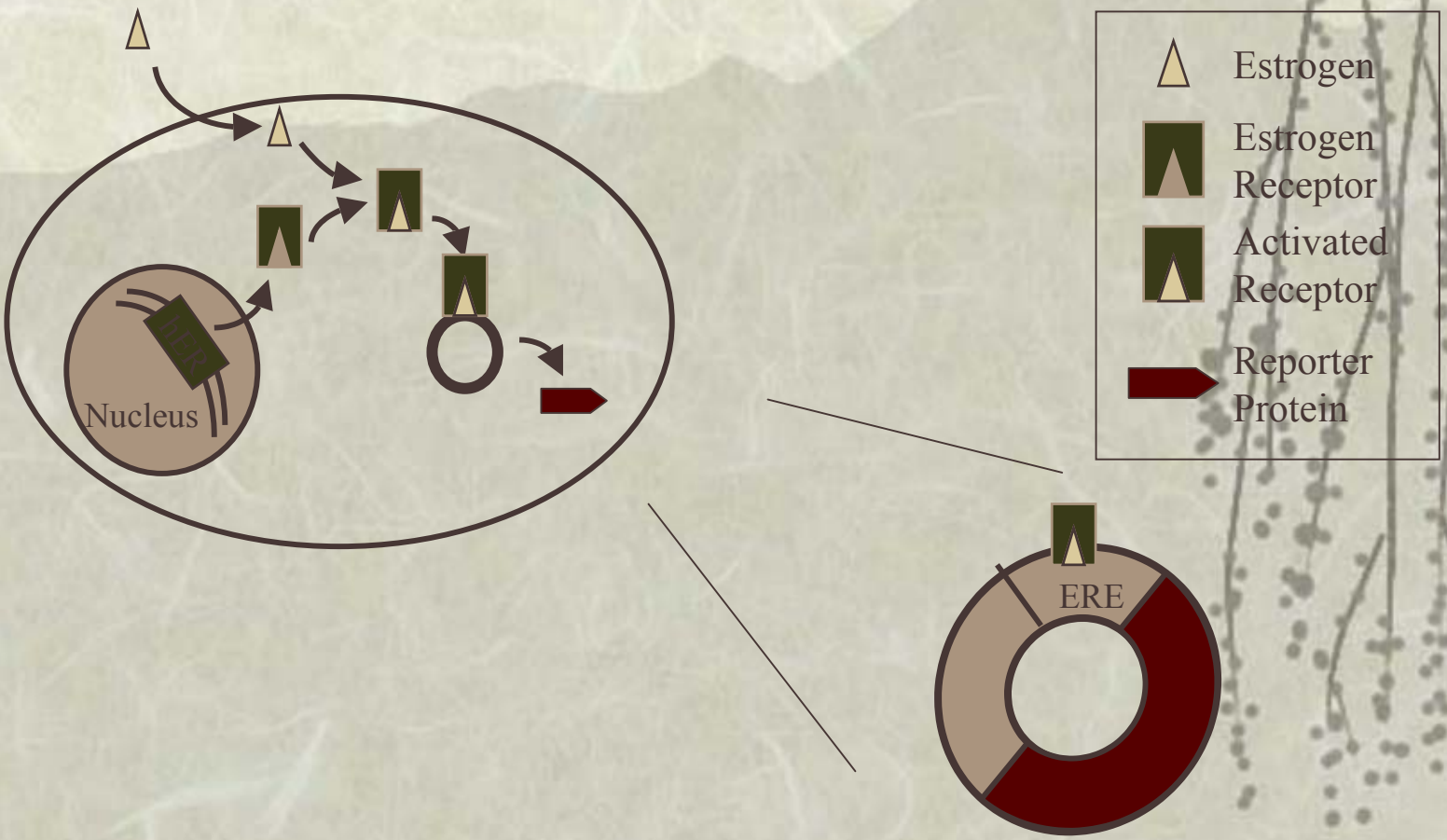
Nonylphenol Ethoxylate Analysis

- Liquid and Solid fractions shall be separated and analyzed separately
- Solids shall be extracted
- All fractions will then be concentrated using solid phase extraction (SPE) Extracts from the SPE will be analyzed by normal phase HPLC
- Goals for detection thresholds is 50 ng/L for each alkylphenol ethoxylates

Messenger RNA Assay

Supply samples to NERL for mRNA (vitellogenin) induction analysis in Fathead Minnow

Recombinant Yeast Assay

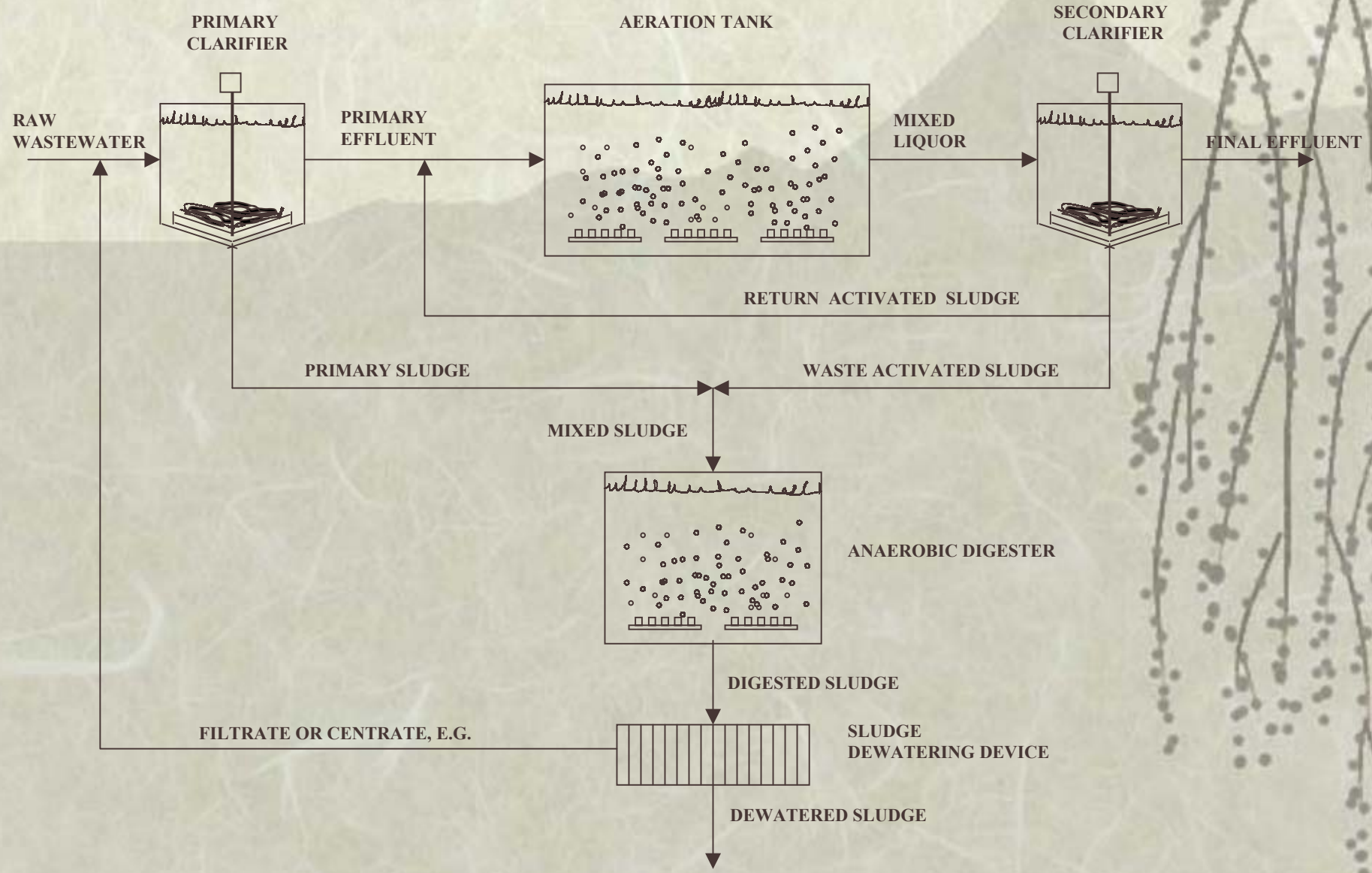


From Routedge and Sumpter, 1996. Environ. Tox and Chem. 15: 241- 248

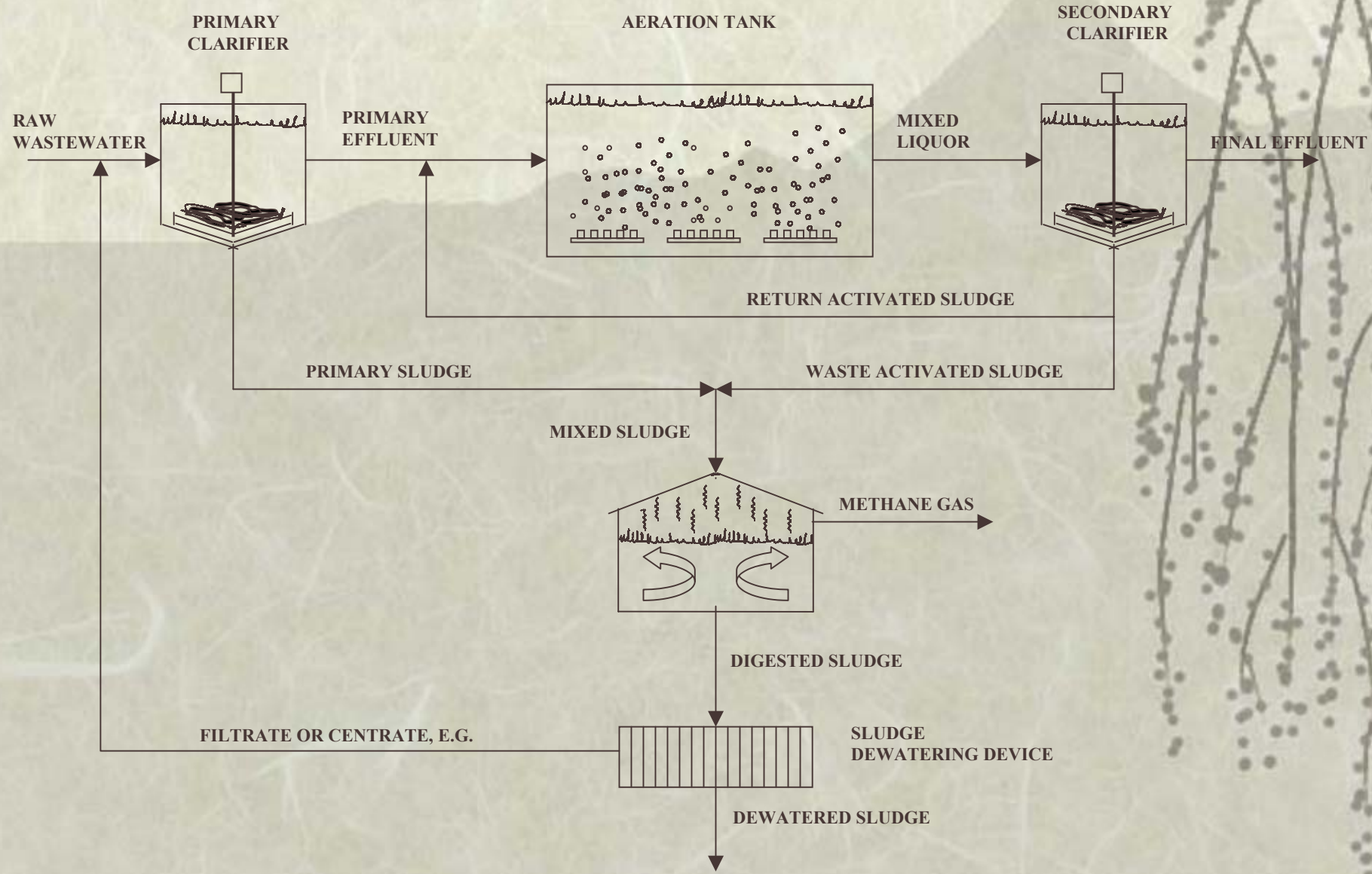
Pilot scale wastewater treatment systems

- EDC Pilot Plant with Aerobic Sludge digestion
- EDC Pilot Plant with Anaerobic Sludge digestion

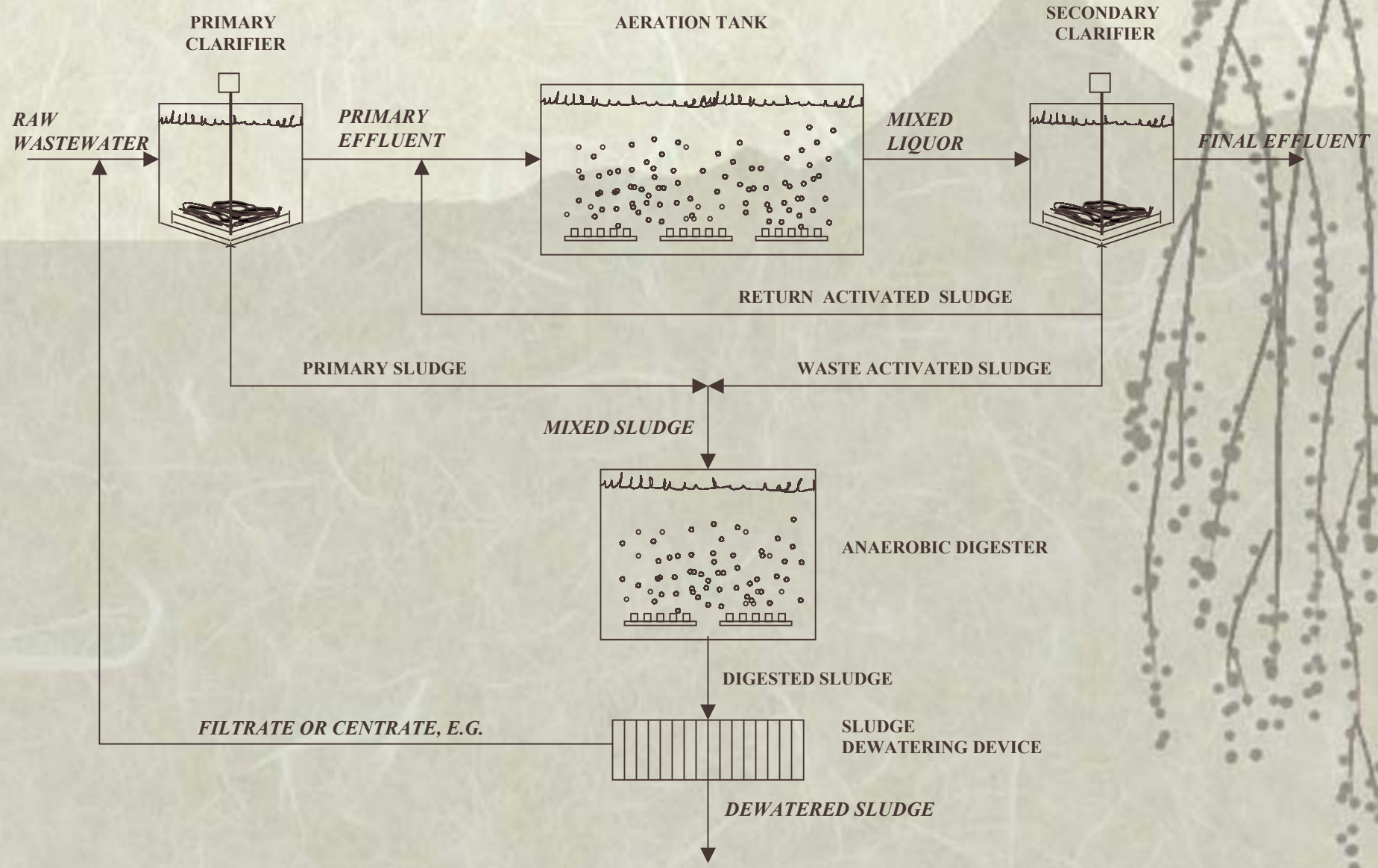
EDC PILOT PLANT FLOWSHEET WITH AEROBIC SLUDGE DIGESTION



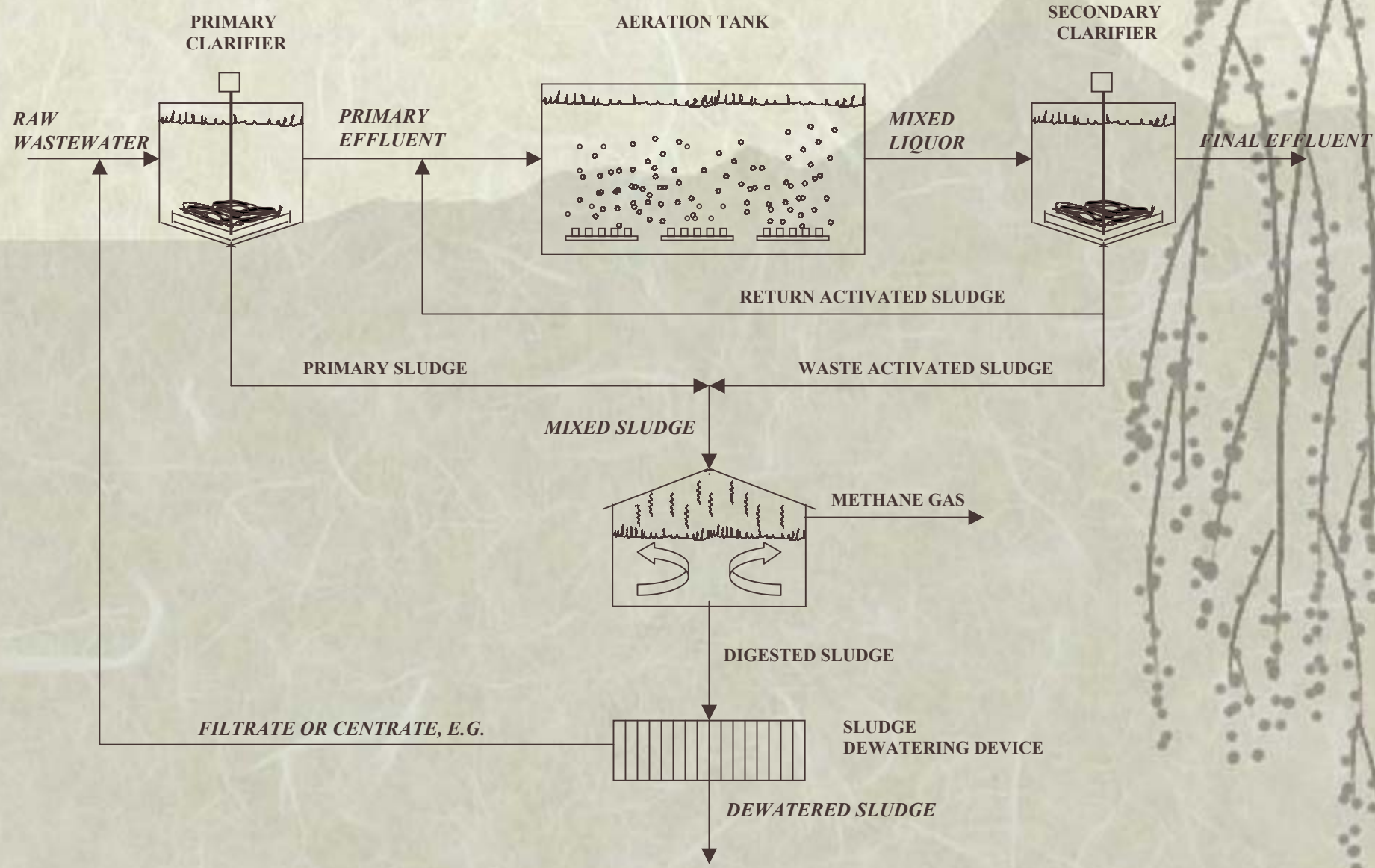
EDC PILOT PLANT FLOWSHEET WITH ANAEROBIC SLUDGE DIGESTION



EDC PILOT PLANT FLOWSHEET WITH AEROBIC SLUDGE DIGESTION



EDC PILOT PLANT FLOWSHEET WITH ANAEROBIC SLUDGE DIGESTION



EDC Pilot Plant

Aerobic Tanks

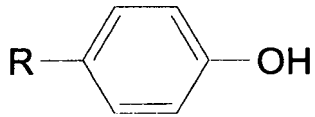
Secondary Clarifier

Anaerobic Digester

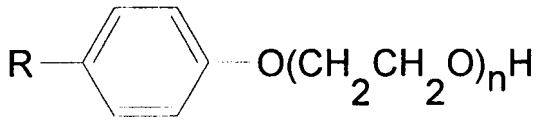
Make recommendations to Improve Treatment of Estrogenic EDCs

- Analyze results of pilot scale systems and modified pilot systems
- Compare results to field results (POTWs)
- Report the generated data and make final recommendations for improved Estrogenic EDC removal. Published as either a journal Article or EPA report

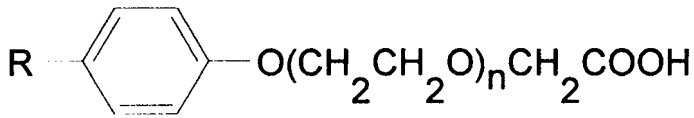
Alkylphenols and Ethoxylates



Alkylphenol



Alkylphenol polyethoxylate



Alkylphenol polyethoxycarboxylate

$R = C_8H_{17}$ (octyl)

$= C_9H_{19}$ (nonyl)

R is usually branched

Metabolic fate of Alkylphenolics